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Letting a Hundred Transgenic Flowers Blossom: The Future of Genetically Modified Agriculture in the People's Republic of China

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LETTING A HUNDRED TRANSGENIC FLOWERS BLOSSOM: THE FUTURE OF GENETICALLY MODIFIED AGRICULTURE IN THE PEOPLE'S REPUBLIC OF CHINA

> China's extraordinary rate of economic development makes it a historically unique, grand-scale socioeconomic and ecological "experiment." No one knows what the future holds, but there is no doubt that the experiment will have an unprecedented impact, not only on the country's own environment and that of its neighbors, but on the world as a whole.[1]

I. Introduction

The People's Republic of China, the world's most populous country and fastest growing economy, faces a host of environmental calamities.[2] Over the next two decades, China will confront a monumental hurdle as it attempts to maintain an adequate food supply.[3] By 2030, the population of China will exceed 1.6 billion people.[4] To keep pace with population growth, China must in-

1. Jingyun Fang & Chia S. Kiang, *China's Environment: Challenges and Solutions*, 4 Frontiers in Ecology and the Env't 339, 339 (2006), *available at* http://www.frontiersinecology.org/specialissue/ESA_Sept06_ONLINE-02.pdf (commenting on China's environmental challenges).

2. *See generally* Charles W. Schmidt, *Economy and Environment: China Seeks a Balance*, 110 Envtl. Health Persp. A 517 (2002), *available at* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241007/pdf/ehp0110-a00516.pdf (describing China's steadily increasing ecological troubles in conjunction with its rapidly expanding economy). In spite of the global recession, China's economy grew at a neck-snapping pace of 8.7 percent in 2009. *China GDP Grows by 8.7 Percent in 2009*, CNN (Jan. 20, 2010), http://www.cnn.com/2010/BUSINESS/01/20/china.GDP.annual/index.htm (stating China's economic growth in 2009). At the same time, serious environmental problems, including deforestation, desertification, erosion, habitat loss, and widespread air, land, and water pollution, plague China. Schmidt, *supra* note 2, at A 517.

3. Leslie Ryan, *GM Crops: Savior or Saboteur? Agricultural Biotechnology in China Today*, 2001 Colo. J. Int'l Envtl. L. & Pol'y 203, 206 (2001) (illustrating hindrances for sustainable agriculture in China); *see also* Martin Walker, *China and the New Era of Resource Scarcity*, 13 World Pol'y J. 8, 8 (1996) (describing dawn of new era complicating China's global economic accession).

4. Qifa Zhang, *China: Agricultural Biotechnology Opportunities to Meet the Challenges of Food Production*, *in* Agricultural Biotechnology and the Poor 45, 45 (G.J. Persley & M.M. Lantin eds., 1999) (projecting that China's population will reach 1.6 billion by 2030).

crease agricultural production by at least sixty percent, nearly forty-five percent of which must be achieved by 2020.[5] A deteriorating environment, however, stands in the way of meeting this demand.[6] With a speed that parallels its surging economy, China's environmental problems mount: water pollution plagues human health and agricultural productivity; rising levels of soil erosion cause cultivable land to teeter on the edge of sustainability; and desertification rapidly consumes much of the country's arable land.[7]

To overcome – and hopefully halt – these impending ecological disasters, the Chinese government has turned to biotechnology.[8] The Communist Party views transgenic crops as the cure for China's woes, believing these genetically modified crops will solve the nation's food crisis, sustain agricultural development, and improve the environment.[9] Nevertheless, the value of transgenic crops is far from conclusive, and the full implications of any widespread use are difficult to predict.[10]

Proponents of biotechnology paint it as a panacea, claiming that transgenic crops will drastically increase agricultural yields and simultaneously improve the environment.[11] Yet, opponents intensely resist such claims, arguing that biotechnology could unleash an irreversible series of environmental, agricultural, and human health disasters.[12] One thing is certain, however: China's ability to reap the potentially spectacular benefits of biotechnology will be

5. *See id.* (noting that population growth requires China to increase food production by at least sixty percent).

6. *See* Joshua Muldavin, *The Paradoxes of Environmental Policy and Resource Management in Reform-Era China*, 76 ECON. GEOGRAPHY 244, 263 (2000) (explaining how environmental degradation quickly demises country's precious, and already scarce, farming acreage). China has only seven percent of the earth's arable land, but must feed over twenty percent of the world's population. *Id.*

7. *Environmental Problems in China*, WWF, http://www.panda.org/who_we_are/wwf_offices/china/environmental_problems_china/ (last visited Oct. 26, 2010) (describing different environmental challenges China is currently facing).

8. *See* Jikun Huang et al., *Agricultural Biotechnology Development, Policy and Impact in China*, ECON. & POL. WKLY., July 6, 2002, at 2761 (describing Chinese government's attitude toward agricultural biotechnology). Today, biotechnology ranks as one of China's highest national priorities. *Id.*

9. *See* Hans van Meijl & Frank van Tongeren, *Biotechnology Boosts to Crop Productivity in China: Trade and Welfare Implications*, 75 J. OF DEV. ECON. 27, 28 (2004) (noting obstacles China hopes to overcome with bioengineered agricultural system).

10. *See* Zhi-Hong Xu & Shu-Nong Bai, *Impact of Biotechnology on Agriculture in China*, 7 TRENDS IN PLANT SCI. 374, 375 (2002) (elucidating that transgenic crops present unknown future implications due to novelty of biotechnology).

11. *See* Huang, *supra* note 8, at 2756 (featuring possible benefits from China's biotechnology use).

12. *See id.* at 2759 (detailing potential negative ramifications of transgenic crops in China).

severely hampered if it does not properly regulate transgenic crops.[13]

China will play a crucial role in determining the prevalence of transgenic agriculture on an international scale.[14] With proper regulation, transgenic crops could provide China with substantial benefits and may solve the country's imminent social troubles.[15] The issues surrounding transgenic crops are multi-faceted, and China must address a variety of questions as it develops policies regarding these new technologies.[16]

This Comment examines the use of biotechnology to combat China's looming environmental crisis and analyzes the country's regulatory framework for transgenic crops. Part II of this Comment sets forth the background of genetic modification and agronomic applications of biotechnology.[17] Part III discusses the agricultural and environmental impacts of using transgenic crops in China.[18] Part IV addresses China's regulation of agro-biotechnology, a field that intersects with agriculture, the ecosystem, intellectual property protection, and international agreements.[19] Finally, Part V suggests that biotechnology may indeed be China's savior while advocating a cautious approach and proper regulation to ensure that transgenic crops do not instead become the country's saboteur.[20]

II. A PRIMER ON GENETIC MODIFICATION

Genetically modified crops have existed since the advent of agriculture itself.[21] Long before biotechnology, farmers employed se-

13. *See id.* (discussing need for proper regulation).

14. *See id.* at 2757 (depicting China's preeminent development of biotechnology and impact of its efforts on global transgenic agriculture).

15. *See id.* at 2759-60 (explaining benefits from biotechnology reaped by Chinese farmers).

16. *See* Huang, *supra* note 8, at 2758-61 (describing complexity of biotechnological legal field and proper regulation of agricultural biotechnology).

17. For a discussion of the background of genetic modification in agriculture, see *infra* notes 21-39 and accompanying text.

18. For a discussion of the impact of biotechnology on agriculture and the environment, see *infra* notes 40-123 and accompanying text.

19. For a discussion of China's current regulatory scheme, see *infra* notes 124-218 and accompanying text.

20. For a discussion of the legal issues involving biotechnology and transgenic crops, see *infra* notes 219-32 and accompanying text.

21. *See* Ryan, *supra* note 3, at 204 (defining genetic modification broadly as any human manipulation of genetic material). In the modern sense, however, genetic modification "involve[s] bioengineering parts of living organisms, manipulating the chromosomes or DNA strands, or the genetic sequences that control specific traits" by means of biotechnology. *Id.*

lective breeding to influence trait expression.[22] Farmers saved only those seeds that produced the most desirable crops from prior harvests for reuse in a subsequent planting.[23] Today, biotechnology presents a superior way to manipulate genetic material.[24]

Genetic modification, in its modern form, operates at the molecular level through in vitro modification of deoxyribonucleic acid (DNA).[25] All living things, from the simplest single-cellular organism to the most complex, contain DNA.[26] Embedded in every strand of DNA are thousands of genes, each of which controls the expression of a specific trait.[27] Organisms derive their uniqueness from the genetic combination programmed within every strand of DNA.[28]

Through modern technology, scientists are now able to extract a specific gene related to a particular trait from one organism and insert that gene into another organism.[29] The new genetic material subsequently directs the production of specific proteins that are normally alien to the host organism.[30] The product of this process is commonly termed "genetically modified," "genetically engineered," "bioengineered," or "transgenic."[31]

Biotechnology offers numerous advantages over selective breeding by affording a more precise, efficient, and expansive form of genetic modification.[32] In terms of precision, biotechnology is

22. *See The North American Symposium on the Judiciary and Environmental Law: The Future of Biotechnology Litigation and Adjudication*, 23 PACE ENVTL. L. REV. 83, 84 (2006) [hereinafter *The North American Symposium*] (explaining selective breeding techniques).

23. *See id.* (describing how crops were developed through traditional breeding techniques).

24. *See id.* at 84-85 (demonstrating superiority of biotech processes in trait enhancement of organisms). While effective in improving crop varieties, genetic modification through breeding is time-consuming, labor-intensive, and imprecise. *Id.*

25. *See id.* at 85 (elaborating on biotech process for genetic modification).

26. *See id.* (describing DNA as building block of life).

27. *See The North American Symposium*, *supra* note 22, at 85 (explaining that genetic material directs production of specific proteins).

28. *See id.* (clarifying DNA's role in generating biological distinctiveness).

29. *See id.* (noting because DNA building blocks for all living things are similar, desirable genes from any living organisms can be inserted into any other living organism). These applications of biotechnology use recombinant DNA (rDNA) techniques and are referred to as rDNA genetic modification. *Id.*

30. *See id.* (stating that genetic material in host organism replicates usual action it has within native organism).

31. *See id.* (referencing rDNA modified organisms).

32. *See* Gregory N. Mandel, *Gaps, Inexperience, Inconsistencies, and Overlaps: Crisis in the Regulation of Genetically Modified Plants and Animals*, 45 WM. & MARY L. REV. 2167, 2175-76 (2004) (illuminating benefits of biotechnology that make it advantageous form of genetic modification).

light-years ahead of traditional breeding methods.[33] Selective breeding can result in fairly random outcomes because it requires procreating an entire organism and all of its genetic material.[34] Biotechnology, conversely, allows a target gene to be isolated and thereby controls the desired trait without concurrently altering a variety of other characteristics.[35] Moreover, biotechnology drastically reduces the labor- and time-intensive nature of genetic modification.[36] As opposed to the generations of focused breeding necessary to enhance trait expression with selective breeding, biotechnology can instantly alter an organism's genetic composition through direct gene insertion.[37] Most significantly, biotechnology vastly expands the available combinations of genetic material.[38] Whereas conventional cross-breeding techniques limit genetic manipulation to members of the same species, biotechnology transcends the species divide and permits DNA transfer "between organisms from different genera, families, orders, classes, phyla, and even kingdoms."[39]

III. BENEFITS AND RISKS OF AGRICULTURAL BIOTECHNOLOGY

Biotechnology enables scientists to give plants a panoply of useful traits to resist an array of pressures ranging from biotic to abiotic stress.[40] These advantages do not, however, come risk-free.[41] This

33. *See id.* (describing speed advantages of biotechnological genetic manipulation).

34. *See id.* at 2175 (explaining drawbacks of conventional modification from breeding entire organism).

35. *See id.* (noting that biotechnology does not face same encumbrance because only gene itself is required for modification process).

36. *See id.*(mentioning biotechnology's revolutionary gains in efficiency).

37. *See* Mandel, *supra* note 34, at 2175 (contrasting genetic modification processes).

38. *See id.* (describing increase in accessible genetic material for enhancing desired traits).

39. *See* John Charles Kunich, *Mother Frankenstein, Doctor Nature, and the Environmental Law of Genetic Engineering*, 74 S. CAL. L. REV. 807, 812 (2001) (discussing effects of transferring DNA beyond species divide). Crops with cold resistance genes from bacteria and fish, for instance, demonstrate the latitude biotechnology affords. *Id.*

40. *See id.* at 817 (describing vast range of enhanced traits provided by bioengineering). Examples of useful traits include resistance against biotic strains, such as disease and insects; abiotic strains, such as drought and cold weather; and tolerance against farmer-sprayed herbicide. *Id.* Additionally, the altered organisms can be given faster growth rates, increased productivity and reproductive potential, as well as a larger size. *Id.*

41. *See* Mandel, *supra* note 32, at 2190 (noting that each benefit comes with associated risk).

section discusses the potential benefits and risks of China's use of transgenic crops.

A. Benefits of Transgenic Crops

For China, biotechnology is especially appealing due to the plethora of benefits it can bestow upon the country.[42] Transgenic crops may efficiently generate greater quantities of food, enabling China to satisfy rising agricultural demands while contemporaneously improving the nation's deteriorating environment.[43]

1. Agricultural Gains

Of primary importance to the swelling country of China, transgenic crops may produce harvests with higher yields than those attainable by traditional agrarian techniques.[44] With a population increasing exponentially, keeping pace with food demand is imperative.[45] China must feed more than twenty percent of the world's population on less than an ever-diminishing seven percent of the earth's arable land.[46] Transgenic crops with enhanced production potential may serve as invaluable tools for achieving this feat.[47]

One benefit of transgenic crops is that they can be engineered to withstand insect invasion.[48] For over fifty years, Chinese farmers plagued by infestations have sprayed Bacillus thuringiensis (Bt), a bacterium toxic to insects, on their crops.[49] When used as a topical spray, the Bt toxin generally loses its effectiveness after only a few days.[50] Each year in China, crop loss from pests accounts for billions of dollars in lost revenue.[51] A sizeable portion of this crop loss could be prevented, however, through the use of transgenic vari-

42. For a further discussion on biotechnology's potential beneficial impact on China, see *supra* notes 8-9 and accompanying text.

43. *See* Mandel, *supra* note 32, at 2180 (including agricultural efficiency and environmental protection as societal advantages offered by biotechnology).

44. *See id.* (explaining how transgenic crops may generate greater yields).

45. For a further discussion on the role of Chinese population growth on the country's food crisis, see *supra* notes 4-5 and accompanying text.

46. For a further discussion on the ever-increasing pressures China faces in sustaining agricultural development and food security, see *supra* notes 2-7 and accompanying text.

47. *See* Mandel, *supra* note 32, at 2180-82 (demonstrating important role transgenic varieties may play in reaching agricultural demands).

48. *See id.* at 2180-81 (noting ability to enhance crops with insect resistance).

49. *See* Jikun Huang et al., *Plant Biotechnology in China*, 295 SCIENCE 674, 675 (2002) (highlighting China's previous pesticide use).

50. *See id.* at 675-76 (explaining previous pesticide use in response to developing pest resistance).

51. *See id.* (addressing severe threat to Chinese agricultural production).

eties encoded with Bt genes that trigger the internal production of the pesticide.[52] These so-called "pest-protected" plants may increase harvest yields by innately fortifying the crop against insects throughout the growing season.[53] Information from China's farming regions with certain pest-protected plants demonstrates that a substantial number of transgenic harvests have effectively controlled insects.[54] For example, corn with inherent pest resistance has increased yields by as much as six percent.[55]

Transgenic crops can also be genetically modified to survive herbicide applications.[56] Herbicides generally function indiscriminately, killing every plant with which they make contact.[57] As a result, farmers traditionally apply herbicide to the entire field before planting seeds in order to avoid endangering their harvest.[58] This "pre-emergent" method has varying levels of efficacy because farmers spray herbicide before weeds develop.[59] Transgenic crops augmented with herbicide tolerance, on the other hand, allow farmers to selectively target weeds that emerge after the crop begins to grow.[60] Herbicide-tolerant crops, therefore, increase the effectiveness of herbicides and, in turn, the crop yield.[61]

An additional benefit of transgenic crops is their ability to thwart non-living environmental factors, known as abiotic stress, and disease.[62] Transgenic crops can grow in temperatures, soils, weather, and climates that would normally prohibit cultivation.[63] These conditions exert the greatest strain on crop yield and quality

52. *See* Mandel, *supra* note 32, at 2180-81 (explaining protection provided by Bt crops).

53. *See id.* at 2180-82 (discussing production benefits of pest-protected crops).

54. *See* Carl E. Pray et al., *Five Years of Bt Cotton in China – The Benefits Continue,* 31 PLANT J. (GM Special Issue) 423, 424-426 (2002) (depicting effectiveness of transgenic crops).

55. *See* Mandel, *supra* note 32, at 2181 (highlighting increased yields of Bt harvests).

56. *See id.* (acknowledging trait enhancement can produce herbicide-resistant variety).

57. *See id.* at 2184-85 (noting herbicides' arbitrary lethalness).

58. *See id.* at 2180 (describing traditional pre-emergent practice of applying herbicide).

59. *See id.* (discussing inefficiency of pre-emergent applications).

60. *See* Mandel, *supra* note 32, at 2180 (highlighting herbicide-tolerant crops' greater efficiency).

61. *See id.* (describing production gains from herbicide tolerance).

62. *See id.* (discussing further enhancements increasing ability of transgenic plants to survive).

63. *See id.* (highlighting cultivation range of transgenic varieties).

in China, and resistance to such adversity produces immense benefits for agricultural productivity.[64]

Furthermore, transgenic varieties may derive health benefits from less contact with noxious agricultural chemicals, fewer pest infestations, and a decline in the affliction of disease.[65] Some scientists report that transgenic plants might even have additional, latent vitality over their natural counterparts.[66] While chemical fertilizer helped China feed its population, its abundant use over the past century steadily lowered pH levels to the point that soil degradation now threatens the long-term productivity of farming regions.[67] Healthier transgenic plants, however, need less fertilizer and utilize it more efficiently.[68]

2. *Environmental Gains*

Agricultural efficiencies derived from biotechnology may translate into environmental improvements for China's severely degrading ecosystem.[69] Transgenic crops possessing insect-resistance, herbicide-tolerance, and other biotic and abiotic advantages may prevent serious environmental harms stemming from traditional Chinese agricultural practices.[70]

First, transgenic crops can lessen the nation's use of environmentally harmful pesticides.[71] The effectiveness of pesticides diminishes over time as insects build resistance to the toxicity.[72] As a

64. *See id.* at 2181 (noting productivity gains offered by transgenic crops).

65. *See Leveling the Playing Field and Opening Markets: Negotiating a WTO Agricultural Agreement: Hearing on H.R. 106-50 Before the Subcomm. on Int'l Econ. Policy and Trade of the H. Comm. on Int'l Relations*, 106th Cong. 45-47 (1999) (statement of L. Val Giddings, Vice President for Food and Agriculture, Biotechnology Industry Organization) (explaining benefits of transgenic plants).

66. *See id.* (suggesting bioengineered health benefits).

67. *See* Jeremy Hance, *Chinese Farming Practices are Acidifying Soils*, MONGABAY.COM (Feb. 11, 2010), http://news.mongabay.com/2010/0211-hance_acid-soils.html (explaining that "anthropogenic acidification driven by [nitrogen] fertilization is at least 10 to 100 times greater than that associated with acid rain"). To make matters worse, "soils are [now] approaching pH values at which potentially toxic metals such as Al and manganese (Mn) could be mobilized." *Id.*

68. *See id.* (explaining relation between plant health and fertilizer use).

69. *See id.* (addressing biotechnology's environmental benefits).

70. *See* Pray, *supra* note 54, at 424-26 (stressing transgenic varieties' positive impact on environment).

71. *See* Ruifa Hu & Fangbin Qiao, *Biotechnology as an Alternative to Chemical Pesticides: A Case Study of Bt Cotton in China*, 2003 AGRIC. ECON. 29, 55-58 (examining negative environmental effects caused by pesticides). Further, "[h]eavy pesticide use also can lead to health problems for consumers if they eat foods sprayed with harmful and slowly-degrading pesticides." *Id.* at 57.

72. *See* Ryan, *supra* note 3, at 206 (noting decreasing effectiveness of topical pesticide sprays).

result, Chinese farmers apply greater amounts of pesticide to conventional crops at an ever-increasing frequency.[73] Pest-protected transgenic crops, by contrast, decrease the need for environmentally harmful pesticides.[74] Weakening a farmer's dependence on pesticide thus reduces the amount of toxic chemical residue emitted into the ecosystem.[75] During China's 2001 growing season, for instance, transgenic crops cut pesticide use by forty-six million pounds.[76] Estimates indicate that the introduction of additional transgenic crops may further reduce pesticide use by another 117 million pounds.[77]

Herbicide-tolerant crops offer similar advantages.[78] Under the "pre-emergent" method, farmers planting conventional crops use herbicides to pre-clear fields of weeds.[79] This practice is environmentally deleterious: it incorporates the herbicide into the soil, necessitating more tillage, which, in turn, leads to greater soil erosion, a reduction in the soil's organic matter, and water loss.[80] The pre-emergent method also increases air and water pollution from herbicide runoff.[81] Because transgenic varieties enable farmers to apply herbicides after their crops begin growing without fear that the harvest will be destroyed, the use of herbicides can be limited to those portions of the field where weeds actually appear.[82] Through selective spraying, farmers release fewer herbicides and, consequently, minimize the harmful impact on the environment.[83]

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73. *See* Pray, *supra* note 54, at 424-26 (describing historic increase in pesticide amounts to combat magnified resistance of pests). Currently, farmers resort to "cocktails of organophosphates, pyrethroids and whatever else they [can] obtain (including DDT, although the use of chlorinated hydro-carbons is illegal) – with less and less impact on the pests." *Id.* at 425.

74. *See id.* (discussing how Bt crops reduce need for pesticides).

75. *See id.* (addressing pest-protected plants' positive environmental effects). It must be noted, however, that pest-protected plants are not entirely benign to the environment because they still contain pesticide in their internal tissue. *Id.*

76. *See* van Meijl & van Tongeren, *supra* note 9, at 34 (highlighting Bt crops' decreased need for pesticides).

77. *See id.* at 36 (describing future deduction in pesticide use through commercialization of more transgenic varieties).

78. *See* Mandel, *supra* note 32, at 2185 (noting advantages of herbicide-tolerant crops).

79. *See id.* (mentioning pre-emergent pesticide practice).

80. *See id.* (discussing herbicides' harmful impact on soil).

81. *See id.* (describing herbicides' harmful impact on air and water).

82. *See id.* (explaining ability of transgenic varieties to reduce herbicide application).

83. *See* Mandel, *supra* note 32, at 2185 (illuminating environmental benefits from less herbicide use).

Bioengineered crops may also require less fertilizer, China's leading pollutant, compared to their conventional counterparts.[84] With a perpetually growing population and an agricultural demand to match, China has regularly relied on chemical fertilizer to increase harvest outputs since the early 1900s.[85] Not only is nitrogen fertilizer the leading cause of soil degradation because of its acidic effects, but its runoff contaminates both surface water and groundwater, posing severe threats to the nation's water supply.[86] Furthermore, the ammonia in fertilizer forms nitrous oxide, a potent greenhouse gas.[87] If transgenic crops are endowed with health benefits, whether latent or contracted, then they can drastically cut China's total fertilizer usage.[88]

Lastly, efficiency gains from transgenic crops may relieve the pressure to develop virgin territory and impede habitat loss, one of the greatest threats to biodiversity.[89] During the next two decades, the country's agricultural demands will rise by at least sixty percent.[90] To meet this growth, China must not only increase agricultural efficiency, but also must devote more land to farming because greater harvest production alone will not suffice.[91] Enlarging agricultural acreage, however, comes with repercussions; any significant increase in the amount of agricultural land will have devastating

84. *See* Hance, *supra* note 67 (explaining how agricultural practices are China's primary source of pollution). A government survey found that forty-three percent of the nation's extensive water pollution problem could be linked directly to the use of fertilizer and pesticides. *Id.*

85. *See* Hance, *supra* note 67 (characterizing China's reliance on chemical fertilizer).

86. *See Brian Merchant, 10 Million Tons of Chemical Fertilizer Discharged into China's Water Every Year,* ALTERNET (Jan. 16, 2010), http://www.alternet.org/water/145199/10_million_tons_of_chemical_fertilizer_discharged_into_china%27s_water_every_year (depicting ramifications of Chinese agricultural practice). Chinese farmers use about 525 pounds of nitrogen fertilizer per acre annually, which releases about 200 pounds of nitrogen per acre into the environment. *Id.* China now consumes fertilizer in excess of 32.6 million tons annually, 10 million tons of which ends up discharged into China's water. *Id.*

87. *See* Mark Shwartz, *Study Highlights Massive Imbalances in Global Fertilizer Use,* STANFORD REPORT (June 22, 2009), http://news.stanford.edu/news/2009/june24/massive-imbalances-in-global-fertilizer-use-062209.html (explaining fertilizers' creation of greenhouse gas and effect on global warming).

88. *See* Hance, *supra* note 67 (explaining transgenic crops' enhanced health that could reduce Chinese farmers' dependence on chemical fertilizer).

89. *See* Mandel, *supra* note 32, at 2185-86 (addressing transgenic farming's effect on biodiversity).

90. *See* Zhang, *supra* note 4, at 45 (noting increase in production demands).

91. *See* Mandel, *supra* note 32, at 2186 (identifying only ways to achieve greater agricultural production as increasing yield efficiency or devoting more land to agriculture).

ecological effects.[92] Thus, China should focus on increasing harvest yields in concert with curtailing further deterioration of existing farmland.[93]

B. Risks of Transgenic Crops

Despite the purported benefits, biotech critics declare that China's use of transgenic crops will only unleash a global parade of horribles, adversely affecting the environment and agriculture on a variety of levels.[94] A common anthem exists among the advocates of transgenic crops: biotechnology is simply a modern means for reaching traditional ends.[95] While superficially valid, this assertion shrouds many of biotechnology's distinguishing features.[96] The most critical difference between biotechnology and selective breeding is that biotechnology makes it possible to "cross the species barrier" and encode the DNA of one organism into that of an entirely different species.[97] This ability to shift genetic traits amongst any living creature accounts for all of biotechnology's benefits, but it is also the source from which all fears permeate.[98]

The overarching fear is that transgenes, the bioengineered segments of DNA from transgenic plants, will escape and enter the genetic material of wild varieties.[99] "Gene flow," as the phenomenon is known, predominately occurs when transgenic varieties outcross with natural, non-modified relatives through pollen dispersal.[100] The product is a hybrid species that possesses co-min-

92. *See id.* (explaining destructive environmental effects of greater farmland development).

93. *See id.* (discussing how increased yield efficiency would reduce pressure to develop natural habitats and benefit ecosystem).

94. *See* Huang, *supra* note 8, at 2756 (noting criticisms of genetically modified crops).

95. *See* Mandel, *supra* note 32, at 91 (describing maxim for supporting biotechnology).

96. *See* Kunich, *supra* note 39, at 812 (explaining how vast distinction between two forms of genetic modification creates enormous potential benefits as well as risks).

97. *See id.* (distinguishing between two forms of genetic modification due to vast taxonomic groups bridged through biotechnology).

98. *See id.* (noting that modern crossbreeding methods possess enormous risks and rewards).

99. *See* Mandel, *supra* note 32, at 2194-95 (discussing fear of gene flow from transgenes).

100. *See id.* (describing cross-pollination process). Transgenic gene flow may occur by transgenes entering natural ecosystems directly through the dissemination of transgenic seeds or by genetic material transferring horizontally from a transgenic organism to another organism via virus or bacteria. *Id.*

gled DNA from both parents.[101] Gene flow is not merely theoretical.[102] As one scientist reports, "[t]he relevant question with respect to [cross-pollination] gene transfer is not whether the gene flow will or will not occur, but rather what will be the fate and impact of the escaped transgene in the natural environment."[103]

One danger is the gradual dilution, and possible eradication, of an ecosystem's non-modified gene pool as transgenes pervade existing organisms' DNA.[104] This threat, known as "genetic erosion," became reality in Capulalpan, a small Mexican town with a once-abundant supply of natural corn varieties.[105] For years, countries worldwide used Capulalpan's corn varieties to rejuvenate corn endangered by disease or disaster.[106] Through gene flow, genetic erosion took its toll as fifteen of the town's twenty-two corn varieties eventually contained traces of modified genes.[107] Over time, most, if not all, plants in China's ecosystems could possess transgenic genes.[108]

As a corollary, China's farming industry may become more susceptible to widespread crop failures.[109] When genetic erosion reduces genetic diversity, it makes crops more genetically similar.[110] Genetic uniformity, in turn, causes crops to react similarly to environmental stresses, thus increasing the risk that an entire harvest will succumb to new evolutionary pressures.[111] One researcher aptly elucidated genetic erosion's effect on massive crop disturbances and the ancillary effect on farmers' abilities to overcome it:

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101. *See id.* (noting how modified genes could escape into wild).

102. *See id.* at 2194-98 (addressing probability of gene flow from transgenic varieties occuring).

103. *See* Kunich, *supra* note 39, at 817-21 (highlighting concerns of unintended gene flow).

104. *See* Mandel, *supra* note 32, at 2194 (explaining that gene flow from transgenic plants threatens the genetic integrity of naturally occurring species).

105. *See* Matthew Rich, *The Debate Over Genetically Modified Crops in the United States: Reassessment of Notions of Harm, Difference, and Choice*, 54 CASE W. RES. L. REV. 889, 896-97 (2004) (addressing gene flow's environmental impacts).

106. *See id.* at 896 (illuminating benefits of genetic diversity).

107. *See id.* at 897 (highlighting how transgenic strains may cause irreparable loss of diversity within natural, non-modified gene pool).

108. *See* Mandel, *supra* note 32, at 2194 (describing possibility that transgene flow will throw environment out of balance).

109. *See id.* at 2197 (expressing concern about genetically modified plants making countries more prone to widespread crop disturbances).

110. *See id.* (noting that "widespread success of genetically modified plants will lead to greater uniformity, and conversely less biodiversity, in the farm crop").

111. *See* Klaus Bosselmann, *Plants and Politics: The International Legal Regime Concerning Biotechnology and Biodiversity*, 7 COLO. J. INT'L ENVTL. L. & POL'Y 111, 128-31 (1996) (explaining how genetic erosion could make China's grain resources more vulnerable and decrease country's food security).

> A few years ago, the famous "miracle strain" of rice in the Philippines, IR-8, was hit by tungro disease. Rice growers switched to a further form, IR-20, whereupon this hybrid soon proved fatally vulnerable to grassy stunt virus and brown hopper insects. So farmers moved on to IR-26, a super-hybrid that turned out to be exceptionally resistant to almost all Philippine diseases and insect pests. But it proved too fragile for the islands' strong winds, whereupon plant breeders decided to try an original Taiwan strain that had shown unusual capacity to stand up to winds—only to find that it had been all but eliminated by Taiwan farmers [when] they planted virtually all their ricelands with IR-8.[112]

Additionally, genetic erosion complicates any attempt to surmount these evolving demands with new transgenic varieties as the genetic components necessary for their creation dwindle.[113]

Another threat is the possibility that transgenic plants will cross-pollinate with natural relatives to create super-species.[114] Herbicide-tolerant transgenes, for example, may penetrate the DNA of a wild weed to produce a "superweed" that is resistant to herbicides.[115] Given any number of enhanced characteristics, superweeds may then flourish to the detriment of surrounding plants and any animals that rely on those plants for food or shelter.[116] The derivative risk is a reduction in biodiversity as hybrid varieties outcompete wild species to the point of extinction.[117]

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112. CARY FOWLER & PAT MOONEY, SHATTERING: FOOD, POLITICS, AND THE LOSS OF GENETIC DIVERSITY 50, 70 (University of Arizona Press) (1990) (quoting Norman Myers) (providing example of genetic erosion's effects on crops).

113. *See* Jack R. Kloppenburg, Jr. & Daniel Lee Kleinman, *Seeds of Controversy: National Property Versus Common Heritage*, in SEEDS AND SOVEREIGNTY: THE USE AND CONTROL OF PLANT GENETIC RESOURCES 173, 188 (Jack R. Kloppenburg, Jr. ed., 1988) (highlighting dangers of reduced biodiversity). Agricultural technology companies claim they can solve crop failures by constantly developing new varieties that are tailored to thwart evolving threats. *Id.* This solution is only viable, however, if there is an abundance of diverse genes from which scientists can find new resistance genes. *Id.* As China commercializes transgenic crops, gene flow may eviscerate this genetic base, encumbering the creation of new varieties. *Id.*

114. *See* Mandel, *supra* note 32, at 2195-97 (explaining risk of gene flow from genetically engineered plants and creation of "superweeds").

115. *See id.* at 2195 (identifying gene flow effect on weed species). In both Britain and Canada, for instance, weeds have acquired such resistance through gene flow. *Id.* Some of these hybrid weeds even acquired multiple herbicide-tolerant transgenes from various transgenic plants. *Id.* at 2197.

116. *See* Kunich, *supra* note 39, at 820-22 (discussing hypothesized dangers and benefits of transgenic gene flow to wild species).

117. *See id.* (describing possible loss of biodiversity).

Finally, bioaccumulation will likely impair the long-term advantages of transgenic crops and potentially cause the bioengineered varieties to pose grave agricultural and ecological dangers.[118] Bioaccumulation is the natural accrual of a chemical substance within an organism that gradually increases the organism's resistance to the substance.[119] Typically, farmers increase the amounts of pesticide and herbicide they use as insects and weeds build immunity to the chemicals via bioaccumulation.[120] Bioaccumulation may therefore render each generation of transgenic crops obsolete and continuously necessitate new, more toxic transgenic varieties.[121] The constant presence of toxins in transgenic crops may even cause bioaccumulation to occur more rapidly than with traditional chemicals, escalating the frequency at which more environmentally deleterious varieties are created.[122] In the end, transgenic crops may contaminate China's environment faster and more extensively than traditional topical sprays.[123]

IV. China's Legal Environment: The Law Surrounding Transgenic Plants

Transgenic plants pose unique regulatory challenges because agro-biotechnology straddles a range of fields.[124] Biotechnology and its transgenic creations implicate agricultural, ecological,

118. *See* Rich, *supra* note 105, at 895 (depicting bioaccumulation as primary environmental concern).

119. *See* Fowler & Mooney, *supra* note 112, at 48-49 (explaining phenomenon of bioaccumulation that renders pesticides ineffectual). Researchers from the International Rice Research Institute studied bioaccumulation in planthoppers, an insect that endangers Asian rice harvests, by feeding them a pest-protected variety of rice. *Id.* at 48. In the beginning, most of the insects starved to death. *Id.* After ten generations, the effects of bioaccumulation became evident as the insects survived, and eventually thrived, on the transgenic rice variety. *Id.*

120. *See* Pray, *supra* note 54, at 424-25 (describing typical Chinese agricultural approach toward pest elimination).

121. *See* Rich, *supra* note 105, at 895 (explaining how different and more potent pesticides are continuously needed to counter insects' new resistance to toxins).

122. *See* Mandel, *supra* note 32, at 2197-98 (explaining bioaccumulation's potential effect on insects and subsequent impact on farming); *see also* Kunich, *supra* note 39, at 819-20 (noting that any loss in gene pool complicates attempts to create new transgenic varieties). Because of less adaptability to potential evolving pressures, gene erosion will inhibit overcoming bioaccumulation. *Id.*

123. *See* Mandel, *supra* note 32, at 2197-98 (describing sequence of events that would cause environmental degradation on greater scale than traditional methods).

124. *See* Kunich, *supra* note 39, at 823 (highlighting expanse of bioengineering field).

human health, and intellectual property concerns.[125] China must contemplate food security and environmental protection against the backdrop of international trade agreements and economic development.[126] This section will focus on the regulation of transgenic plants in the People's Republic of China.

A. Seed Regulation in the People's Republic of China

The Seed Law of 2000 regulates seeds in China's agricultural market with the dual aims of safety and quality control.[127] To that end, the legislative framework controls the breeding, production, and dissemination of both wild and transgenic seeds throughout China.[128] Under the Seed Law, all seeds must first obtain release approval by passing a state-conducted safety examination.[129] Article 14 of the Seed Law, in turn, grants the State Council power to establish specific rules for the safety assessment of transgenic seeds, but requires that the method adopted be "strict."[130]

After release approval, an individual must obtain a production and processing license before breeding and marketing the variety.[131] Additionally, if the Regulations on the Protection of New Varieties of Plants (Regulations) protect the seeds, then the breeder must obtain written consent from the rights holder.[132]

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125. *See generally* Charles W. Schmidt, *Genetically Modified Foods: Breeding Uncertainty*, 113 ENVTL. HEALTH PERSPS. A 526 (2005) (explaining dangers of transgenic species).

126. *See generally* Muriel Lightbourne, *Organization and Legal Regimes Governing Seed Markets in the People's Republic of China*, 2006 U. ILL. J.L. TECH. & POL'Y 229, 237-49 (2006) (describing scope and nature of biotech regulation and its role in Chinese agriculture).

127. *See id.* at 243-45 (describing Chinese regulatory regime and legal effect on agriculture).

128. *See id.* (delineating legislative scope of China's Seed Law).

129. *See generally* Seed Law (promulgated by the Standing Comm. Nat'l People's Cong., July 8, 2000, effective Dec. 1, 2000) (P.R.C.), *available at* http://www.grain.org/brl_files/SL_China_Seed_Law_2000.pdf (outlining procedure for ensuring seed quality).

130. *See id.* at art. 14 (stating "safety assessment[s] should be carried out for the selection, breed, test, examination and popularization of gene-transfer plant species, and safety method[s] should be adopted strictly.").

131. *See id.* at art. 21, 29 (mandating production and processing license). For a production license, applicants must fulfill the following requirements: 1) proper conditions for seed propagation; 2) disease and pest free cultivation site; 3) adequate facilities and capital to produce and test the seed; and 4) professional technicians to oversee production and safety inspection. *Id.* at art. 21. For a processing license, on the other hand, applicants must show: 1) sufficient capital to market the seed; 2) qualified personnel to oversee quality control; 3) a facility to process, pack, and store the seed; and 4) the equipment to carry out quality inspections. *Id.* at art. 29.

132. *See id.* (authorizing statutory overlap).

Once awarded both licenses, breeders must distribute the seed in accordance with all labeling procedures.[133]

B. Intellectual Property Protection for Transgenic Plants in China

Traditionally, Chinese culture has been adverse to the concept of intellectual property rights.[134] As China instituted economic reform and opened its doors to foreign markets in the 1970s, however, a new view emerged within the Communist Party.[135] China's leaders sought to stimulate technological development through overseas investment, and, in striding towards that goal, the importance of effective intellectual property protection quickly became manifest.[136] Since 1979, China has progressively increased the extent of its intellectual property rights, in many instances mirroring Western models.[137]

With respect to genetically modified plants, transformation was more gradual.[138] As an emergent country looking to utilize transgenic crops, China requires advanced biotechnology from more developed nations.[139] China therefore needs adequate intellectual property protection to encourage technology transfer.[140] At the same time, however, China needs intellectual property rights that are lenient enough to prevent foreign exploitation of the country's genetic resources.[141] On balance, China must take a middle ground approach: It must exclude transgenic varieties from patent protection, but provide a less stringent, sui generis system of protec-

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133. *See id.* at art. 35 (stating that label must indicate seed variety, name, place of production, quality index, quarantine certificate number, and license number).

134. *See* Chengfei Ding, *The Protection for New Plant Varieties of American Businesses in China After China Enters the WTO*, 6 DRAKE J. AGRIC. L. 333, 338 (2001) (explaining that Confucian ideology promotes morality as driving force behind intellectual innovation rather than monetary interest).

135. *See id.* (describing effect of economic reform on intellectual property rights).

136. *See id.* (explaining Chinese leaders' desire to develop effective intellectual property protections).

137. *See id.* (describing general transformation in Chinese intellectual property law).

138. *See id.* at 339 (noting that China did not afford intellectual property protection for plant varieties until 1997).

139. *See* Leslie Cataldo, *A Dynasty Weaned From Biotechnology: The Emerging Face of China*, 26 SYRACUSE J. INT'L L. & COM. 151, 157 (1998) (depicting China's desire for biotech industry expansion).

140. *See* Ding, *supra* note 134, at 339 (explaining inhibitory effect on scientific development produced by ineffective intellectual property rights).

141. *See id.* (discussing China's competing concerns as it tries to protect itself from foreign exploitation).

tion.[142] In 1997, the National People's Congress took a landmark step in this direction by promulgating the Regulations.[143]

1. *The Regulations on the Protection of New Varieties of Plants*

China ushered in a new era in its history with the Regulations, bringing tremendous progress in the area of intellectual property law.[144] China still excludes plant varieties from patent protection,[145] but the Regulations establish and protect property rights for new plant varieties (Variety Rights) through a sui generis system.[146] Not all transgenic plants qualify for Variety Rights, however; eligibility is restricted to only those species included in the State's Plant Varieties Catalogue.[147] Additionally, each eligible transgenic variety must meet the tests of novelty, distinctiveness, consistency, and stability.[148]

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142. *See id.* (noting that patent protection is more advantageous for plant breeders because no exemptions to exclusive rights exist).

143. *See generally* Regulations on the Protection of New Varieties of Plants (promulgated by State Council, Mar. 20, 1997, effective Oct. 1, 1997) (P.R.C.), *available at* http://www.upov.int/en/publications/npvlaws/china/china.pdf [hereinafter Regulations] (providing regulations to protect rights for new plant varieties).

144. *See* Ding, *supra* note 134, at 349 (discussing implication of Regulations on plant protection).

145. *See* Patent Law, art. 25 (promulgated by standing Comm. of the Sixth Nat'l People's Cong., Mar. 12, 1984, amended Aug. 25, 2000) (P.R.C.), *available at* http://www.chinaiprlaw.com/english/laws/laws4.htm [hereinafter Patent Law] (noting China's lack of patent protection for plant varieties). China does, however, provide patent protection for the techniques that produce plant varieties. *Id.*

146. *See* Ding, *supra* note 134, at 340 (describing sui generis system of protection).

147. *See id.* (discussing plant eligibility requirements); *see also* Lester Ross & Libin Zhang, *Agricultural Development and Intellectual Property Protection for Plant Varieties: China Joins the UPOV*, 17 UCLA PAC. BASIN L.J. 226, 235-37 (2000) (entailing catalogue's span). At present, the catalogue composes forty-one genera and species. *Id.* The list includes grains, vegetables, tobacco, and tea. *Id.* at 238. Over the last decade, the list increased from eighteen to forty-one genera and species, partially as a result of obligations China acquired under the UPOV 1978 Act. *Id.*

148. *See* Regulations, *supra* note 143, at art. 14-17 (describing novel, distinct, consistent, and stable classification requirements). To meet the novel requirement, the plant variety must not have been sold in China for more than one year or for more than four years in a foreign country. *Id.* at art. 14. To be considered distinct, the plant variety "shall have an adequate denomination, which shall be distinguishable from that for any other known plant variety of the same or similar botanical genus or species." *Id.* at art. 15. Consistency refers to the plant variety's retention of its relevant characteristics or specific properties after reproduction. *Id.* at art. 16. Finally, stability refers to the variety's retention of such characteristics or properties after repeated reproduction or a specified reproduction period. *Id.* at art. 17.

Variety Rights entitle individuals to a fifteen year right of exclusivity.[149] During that period, the rights holder is the only individual permitted to produce, sell, or use the plant variety in a commercial manner.[150] Under sui generis systems, however, the object of protection is the variety as a whole, not its constituent genes.[151] Breeders without Variety Rights may consequently generate further varieties for commercial purposes through the use of genes from a protected variety.[152] The Regulations do not, therefore, protect rights holders from potentially far-reaching interests in derivative varieties.[153] This stands in stark contrast to the protection of biotech innovation under typical patent law, which attaches to particular genes and covers varieties attained through the use of those protected transgenes.[154]

The limits set forth in Articles 10 and 11 of the Regulations further constrain the scope of protection for transgenic plants.[155] Article 10 exempts two circumstances from regulatory coverage.[156] First, the Article allows a non-authorized individual to use protected varieties for noncommercial breeding or scientific activities.[157] Second, it grants peasants the ability to use plants, otherwise guarded

149. *See id.* at art. 34. (explaining that individuals have fifteen years of exclusivity for plants and twenty years of exclusivity for vines, forest trees, fruit trees, and ornamental plants). China's Patent Law, on the other hand, grants a twenty year exclusion term for innovations. *See* Patent Law, *supra* note 145, at art. 45.

150. *See* Ding, *supra* note 134, at 340 (describing protective scope of Variety Rights under Regulations). In China, two enforcement mechanisms protect intellectual property: administrative and judicial mechanisms. *Id.* at 346. A Variety Rights holder may seek administrative aid from an agriculture-related government agency, requesting that the alleged infringement be rectified. *Id.* Alternatively, the Variety Rights holder may seek judicial relief in the People's Court. *Id.*

151. *See* Niek van der Graaff, *Agricultural Biological Diversity for Food Security: Shaping International Initiatives to Help Agriculture and the Environment*, 48 How. L.J. 397, 411 (2004) (contrasting sui generis and patent protection for biotech developments).

152. *See* Regulations, *supra* note 143, at art. 6 (detailing right of exclusivity under Article 6 of Regulations).

153. *See* Ross & Zhang, *supra* note 147, at 239-40 (noting limits on Variety Rights that prevent right of exclusion from encompassing derivative varieties). Nonetheless, breeders employing protected varieties' genes as propagating material must obtain authorization from the Variety Rights holder. *Id.* If a breeder uses a variety without authorization, he or she is subject to a fine but not deprived of any product resulting from the process. *Id.*

154. *See* van der Graaff, *supra* note 151, at 411 (comparing patent and sui generis systems of intellectual property protection).

155. *See* Ding, *supra* note 134, at 340-41 (delineating limit on exclusive right to possess plant varieties under Regulations).

156. *See id.* at 340 (explaining two exceptions to Variety Rights under Article 10).

157. *See* Regulations, *supra* note 143, at art. 10 (authorizing research exemption).

by Variety Rights, as propagating material.[158] Thus, peasants may retain and reuse the seeds of protected varieties from one harvest to the next.[159] Article 11, moreover, carves out a public interest exception that allows the Chinese government to circumvent Variety Rights "in the national interest."[160] Under the power of that Article, the Ministry of Agriculture can divest a variety holder of rights and grant compulsory licenses for the use of protected varieties.[161]

The reach of Article 10 and Article 11 is expansive, and the sweeping exemptions could wield distressing effects on the biotech industry and the environment.[162] By disemboweling the intellectual property rights gained through the Regulations, the Articles may impede the growth of the biotech industry and thereby hinder environmental improvements.[163] Article 10's so-called "farmer privilege" greatly diminishes the breadth of Variety Rights by removing "peasants," the socio-economic status of almost all Chinese farmers, from nearly the entire consumer market.[164] Additionally, even if the likelihood of compelled licensing is low, "it exerts a chilling effect on the development and introduction of new plant varieties, particularly in the absence of any clearly stated restrictions (such as a national emergency) on the exercise of such power."[165]

Furthermore, these articles may exacerbate the threats transgenic crops pose by undermining China's regulatory scheme.[166] "[T]here must be a strong regulatory system in place to enable the Chinese government to monitor the type and amount of [transgenic varieties] being used, and to keep an eye out for defects in

158. *See id.* (licensing peasant exemption).

159. *See* Ding, *supra* note 134, at 340-41 (noting Article 10 permits farmers to reuse seeds protected by Regulations).

160. *See* Regulations, *supra* note 143, at art. 11 (empowering Ministry of Agriculture with public interest exception).

161. *See* Lightbourne, *supra* note 126, at 343 (describing Ministry of Agriculture's ability to issue compelled licenses).

162. *See* Ding, *supra* note 134, at 339-46 (discussing extensiveness of Article 10 and 11 exemptions and their possible effects on environment and biotech industry).

163. *See id.* at 344-46 (contrasting effective intellectual property laws with Regulations). In the eyes of the foreign biotechnology sector, the protection provided for plant varieties may be insufficient due to the large amount of investment necessary for developing new transgenic species. *Id.* at 339-43. The limited scope of protection in Article 10, and the compulsory licensing provision of Article 11, subject the biotech industry to enormous risks and an uncertain market. *Id.* at 339-46.

164. *See* Ross & Zhang, *supra* note 147, at 233 (explaining far-reaching impact of farmer privilege on Variety Rights).

165. *See id.* (addressing lack of controls on government's power to issue compelled licenses because Regulations do not define "national" or "public" interest).

166. *See* Ryan, *supra* note 3, at 213 (describing transgenic crops' adverse effect on environment).

[genetically modified] technology."[167] Articles 10 and 11, however, exclude a wide range of activities from monitoring and could obstruct transgenic plant regulation.[168]

2. *International Convention for the Protection of New Varieties of Plants*

In 1999, to complement the regulatory scheme enacted just two years before, China joined the International Convention for the Protection of New Varieties of Plants (UPOV) by signing its 1978 Act.[169] Amid the myriad of national systems, this Act functions as a floor, ensuring a minimum level of property rights for breeders of new plant varieties.[170]

To comply with its international obligations, China enlarged the protective scope of the Regulations, extending Variety Rights to the citizens of each UPOV-member state.[171] The exclusion right afforded in the Regulations is largely in line with the UPOV's 1978 Act.[172] The Act does not, however, provide an exception for farmers' self-use as Article 10 of the Regulations permits.[173] Compulsory licensing under Article 11, on the other hand, is entirely consistent with the Act, which allows suspending the right of exclusion for public interest reasons.[174]

China's accession to the 1978 Act, rather than the UPOV's subsequent 1991 Act, demonstrates an unwillingness to assume more demanding obligations and illustrates the country's present middle-path approach to protecting agro-biotech innovations.[175] The 1978 Act is less stringent than its successor in several crucial aspects.[176] First, under the 1978 Act, only specific genera and varieties are eli-

167. *See id.* (elaborating on appropriate regulatory regime).

168. *See* Regulations, *supra* note 143, at art. 11 (describing exemptions' scope).

169. *See* Ding, *supra* note 134, at 341-42 (addressing complementary nature of UPOV).

170. *See id.* (discussing regulatory structure).

171. *See* Ross & Zhang, *supra* note 147, at 238 (explaining enlargement of regulatory scheme).

172. *See id.* at 239 (aligning Regulations' regulatory scope with China's UPOV commitments).

173. *See id.* at 240 (noting regulatory gap between China's commitment under UPOV and reach of Regulations). It is still too early to tell what international ramifications this disjuncture will bring. *Id.*

174. *See id.* at 239-40 (analyzing validity of China's public interest exemption under UPOV).

175. *See id.* at 239-41 (illustrating China's regulatory approach).

176. *See* Ding, *supra* note 134, at 341-42 (comparing major differences between UPOV's 1978 and 1991 Acts).

gible for protection.[177] The 1991 Act, however, extends protection to all plants without regard to any classification.[178] Second, the 1978 Act prohibits simultaneous protection under both a patent and sui generis system.[179] The 1991 Act, conversely, permits a legislative scheme that provides dual protection under both systems.[180] Third, under the 1978 Act, the right of exclusion does not cover variations derived from the genes of a protected variety.[181] The 1991 Act, on the contrary, expands the protective scope to include derivative varieties, reflecting a patent system.[182]

3. *The Agreement on Trade Related Aspects of Intellectual Property Rights*

On December 11, 2001, the People's Republic of China became the 143rd member of the World Trade Organization (WTO).[183] Membership requires compliance with the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs), the WTO's regime on intellectual property protection.[184] TRIPs Article 27 commands member-states to protect plant varieties with either a patent or an "effective sui generis" system, or any combination of the two.[185] While TRIPs does not define "effective," common perception holds that any structure modeled after the UPOV's 1978 Act meets the appropriate standard.[186] As a TRIPs signatory, China further extends Variety Rights to all WTO member-states.[187] Thus, despite the one variation between the Regulations and the 1978 Act, the intellectual property protection China affords is likely consistent with the WTO mandate.[188]

177. *See* Ross & Zhang, *supra* note 147, at 240 (noting 1978 Act's limited eligibility).

178. *See id.* at 240-41 (describing 1991 Act's expansive scope).

179. *See id.* (discussing 1978 Act's narrow regulatory structure).

180. *See id.* (elaborating on 1991 Act's extended regulatory structure).

181. *See id.* (examining 1978 Act's exclusion of derivative varieties from regulatory converge).

182. *See* Ross & Zhang, *supra* note 147, at 241 (analyzing enlarged regulatory reach of 1991 Act).

183. *See* Ding, *supra* note 134, at 342 (noting China's accession to World Trade Organization).

184. *See id.* (discussing WTO intellectual property mandate).

185. *See id.* at 343 (describing regulatory system required under TRIPs).

186. *See id.* (noting classification of "effective" sui generis system).

187. *See id.* at 342 (addressing steps China makes to comply with TRIPs).

188. *See* Ding, *supra* note 134, at 343 (concluding that China complies with TRIPs' demands).

4. *The United Nations Convention on Biological Diversity*

At the 1992 Earth Summit, 179 countries, including China, formed the Convention on Biological Diversity (Convention) with the "conservation and sustainable use of biological diversity" as its goal.[189] Specifically, the Convention seeks to create "an enabling environment for the environmentally sound application of biotechnology," allowing countries to reap the "maximum benefit from the potential that biotechnology has to offer, while minimizing possible risks to the environment and human health."[190]

In order to achieve these goals, Article 15 mandates that members exchange genetic resources to promote the sustainable use of biological diversity.[191] Further, Article 15 requires equitable distribution of the benefits arising from the research and development of those genetic resources.[192] At first glance, the Convention facilitates the development and transnational transfer of biotechnology and transgenic plants.[193] Upon further analysis, however, the Convention may actually impede technological advances because strict adherence to the Convention's text means that a company seeking China's genetic resources must forego a portion of its intellectual property rights granted under the Regulations and TRIPs.[194]

C. Ecological Security: Biosafety in the People's Republic of China

Biosafety is the comprehensive management of biological risks to protect the environment in conjunction with plant, animal, and

189. Ross & Zhang, *supra* note 147, at 241-42 (describing Convention's goal to prevent adverse impacts on conservation and promote sustainable use of biological diversity).

190. United Nations Convention on Biological Diversity, *opened for signature* June 5, 1992, 1760 U.N.T.S. 79, 31 I.L.M. 818 [hereinafter Convention on Biological Diversity] (laying out purposes of Convention).

191. *See id.* at art. 15 (requiring exchange of genetic resources to meet Protocol objectives).

192. *Id.* (commanding exchange of benefits).

193. *See id.* (enumerating actions and goals of contracting parties).

194. Amy Nelson, *Is There an International Solution to Intellectual Property Protection for Plants?*, 37 GEO. WASH. INT'L L. REV. 997, 1014 (2005) (elaborating on apparent conflict between Protocol and TRIPs regarding intellectual property protection). In particular, "Article 16(5) stipulates that contracting parties should cooperate to ensure that intellectual property rights do not run counter to the objectives of the CBD [Convention on Biological Diversity]." *Id.* Yet, "[b]y advocating resource conservation and state ownership over plant genetic resources, the CBD appears to be in conflict with TRIPs, which allows patenting, and therefore privatization, of plant genetic resources." *Id.*

human health.[195] The core concerns regarding the use of transgenic crops fall within the ambit of biosafety.[196] Environmentally speaking, biosafety encompasses the preservation of biological diversity.[197] Ensuring biodiversity is therefore extremely important for China, one of the world's most genetically rich countries.[198]

1. *The Cartagena Protocol on Biosafety*

In 1999, Convention member-states held a conference in Colombia that culminated with the creation of the Cartagena Protocol on Biosafety (Protocol).[199] China signed the Protocol the following year.[200] Generally, the Protocol requires signatories to protect biological diversity and human health from the risks posed by transgenic organisms.[201] As a result, Article 16 of the Protocol imposes certain risk analysis measures on participants to prevent any adverse effects of bioengineered organisms.[202] The Protocol also instructs members in the development, handling, and use of transgenic plants.[203] Each country may implement its own regulatory framework for biosafety so long as the scheme complies with Protocol guidelines.[204]

195. *See* van der Graaff, *supra* note 151, at 428 (elucidating objectives of biosecurity).

196. *See id.* 416-20 (enumerating core environmental concerns).

197. *See id.* (describing environmental biosafety as biological preservation).

198. *See id.* (espousing virtues of biological diversity for China's ecosystem).

199. Ross & Zhang, *supra* note 147, at 242 (discussing China's succession to Protocol).

200. *See id.* (noting China's participation as full member of Protocol).

201. *See generally* Cartagena Protocol on Biosafety to the Convention on Biological Diversity, May 24, 2000, 2226 U.N.T.S. 208, 39 I.L.M. 1027 [hereinafter Protocol] (establishing that members will control risks associated with using transgenic organisms that are likely to adversely impact environment); *see also* Ryan Hill & Cyrie Sendashonga, *Conservation Biology, Genetically Modified Organisms, and the Biosafety Protocol*, 20 CONSERVATION BIOLOGY 1620, 1622-24 (2006) (explaining key elements of Protocol).

202. *See* Protocol, *supra* note 201, at art. 16 (asserting underlying biosafety agenda of risk identification, assessment, and containment).

203. *See id.* at art. 1 (setting level of protection against adverse effects on conservation and sustainable use of biological diversity).

204. *See* Sara M. Dunn, *From Flav'r Sav'r to Environmental Saver? Biotechnology and the Future of Agriculture, International Trade, and the Environment*, 9 COLO. J. INT'L ENVTL. L. & POL'Y 145, 158 (1998) (explaining state responsibility for conserving biological resources in sustainable manner by conserving ecosystems and genetic materials).

2. *China's Regulatory Framework for Biosafety*

China controls biosafety on three levels: national, ministerial, and regional.[205] The various layers and agencies implicated in the regulation render this area of law particularly complex.[206] At the national level, the Ministry of Science and Technology (MOST) directs the country's biosafety management.[207] The National Centre of Biological Engineering Development, in turn, administers new regulations and coordinates exchange between the different ministries involved in biosafety governance.[208]

At the ministry level, biosafety management is a concerted effort amongst several ministries, departments, and agencies.[209] The Ministry of Agriculture (MOA) formulates and, with the help of the Office for Agricultural Genetically Modified Organisms, implements biosafety regulations.[210] Additionally, the Biosafety Committee on Agricultural Biological Engineering, a subdivision of the MOA, handles the biosafety assessment that transgenic plants must pass before receiving commercial approval.[211]

The State Environmental Protection Agency (SEPA), on the other hand, is responsible for the post-release safety of the environment and monitors the ecological impact of approved transgenic varieties.[212] The SEPA, consequently, administers the Protocol's guidelines.[213] Finally, at the regional level, the Chinese government enhances local capacity to deal with biotechnology.[214]

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205. *See* Huang, *supra* note 8, at 2758 (discussing layers of biosafety management in China).

206. *See id.* at 2759 (explaining complexities of Chinese regulatory web).

207. *See id.* (describing MOST's role in biosafety management).

208. *See* Ross & Zhang, *supra* note 147, at 243-44 (depicting underlying administration of biosafety regulations).

209. *See* Huang, *supra* note 8, at 2758 (noting interlocking functions of various governmental branches).

210. *See id.* (elaborating on formulation and implementation of biosafety regulations).

211. *See id.* at 2759 (examining commercial approval evaluation of experimental research and field trials). In 2001, the State Council adopted the Agricultural Genetically Modified Organism Safety Regulations. *Id.* The law adds an extra trial stage prior to commercial approval; processing regulations; labeling requirements for marketing; import and export regulations; and local and provincial monitoring guidelines. *Id.*

212. *See id.* (noting SEPA's monitoring role).

213. *See id.* (discussing SEPA's Protocol administration). Furthermore, the Ministry of Health ensures the safety of transgenic products for human consumption. *Id.*

214. *See* Huang, *supra* note 8, at 2758 (explaining regulation at local level). At present, thirty-one committees exist at the provincial level and about 2,500 exist at the county level. *Id.*

The Regulations on Genetic Engineering, which the MOST issued in 1993, contain China's general biosafety control measures for biotechnology.[215] In 1996, the MOA's Regulations on Agricultural Biological Genetic Engineering supplemented these general guidelines with specific biosafety measures for transgenic plants – something a majority of countries lack.[216] Additionally, in 2001, the SEPA issued the Safety Administration Regulation on Agricultural Genetically Modified Organisms.[217] The SEPA is also "preparing an all-embracing national level set of biosafety regulations and a biosafety law which will encompass the MOA regulations."[218]

V. CONCLUSION

China has become a world leader in environmental degradation.[219] Today, China's environment is in such a state of disarray that it threatens the country's social stability.[220] As Pan Yue, Vice Minister of the SEPA, warned in 2005, "[t]he [economic] miracle will end soon because the environment can no longer keep pace."[221] If China is going to emerge as an economic superpower, it must avoid committing ecological suicide.[222] Only by creating a

215. *See* Lightbourne, *supra* note 126, at 242 (describing regulatory framework consisting of general principles, safety classes and evaluation guidelines, as well as legal responsibilities).

216. *See* Huang, *supra* note 8, at 2759 (identifying further regulatory measures for biosafety management).

217. *See* Lightbourne, *supra* note 126, at 242 (explaining SEPA's issuance of safety regulations).

218. *See* Huang, *supra* note 8, at 2759 (analyzing future biosafety regulatory framework).

219. *See* Muldavin, *supra* note 6, at 250 (elaborating on China's environmental deterioration).

220. *See* Joseph Kahn & Jim Yardley, *As China Roars, Pollution Reaches Deadly Extremes*, N.Y. TIMES, Aug. 26, 2007, at A1, *available at* http://www.nytimes.com/2007/08/26/world/asia/26china.html (describing environmental degradation as so severe that pollution poses major long-term burden on Chinese public and acute political challenge to Communist Party).

221. *SPIEGEL Interview with China's Deputy Minister of the Environment: "The Chinese Miracle Will End Soon,"* SPIEGEL ONLINE (Mar. 7, 2005), http://www.spiegel.de/international/spiegel/0,1518,345694,00.html(relating China's serious pollution problems); *see also* Kahn & Yardley, *supra* note 220 (explaining that environmental and political calculus is so daunting that "[r]eining in economic growth to alleviate pollution" is only option).

222. *See* Kahn & Yardley, *supra* note 220 (noting that China's leaders acknowledge country must change course). The Communist Party "vow[s] to overhaul the growth-first philosophy of the Deng Xiaoping era and embrace a new model that allows for steady growth while protecting the environment." *Id.* China commenced that model with a $175 billion environmental relief package with the specific aims of reducing water pollution and cutting soil erosion. *Id.* In a recent address to the nation, Premier of the People's Republic of China, Wen Jiabao, made forty-eight references to the "environment," "pollution," or "environmental

sustainable system of agriculture can the country propel itself forward over the next century.[223]

Biotechnology is one tool that might help China accomplish this goal, but it is not a cure-all.[224] Transgenic crops have the potential to revolutionize agriculture and help feed a rapidly increasing population; however, transgenic crops may also cause far-reaching, and perhaps irreparable, damage to China's environment and agricultural development.[225] Consequently, the Chinese government must carefully regulate the use of transgenic plants to ensure China's environmental security and the nation's long-term viability.[226]

At this moment, the regulatory framework in place appears fairly strong, but only time will reveal its actual merit.[227] Unfortunately, while Beijing sets the country's agenda, it does not control all aspects of its implementation.[228] Local officials seldom heed the central government's environmental mandates, preferring instead to concentrate on advancing economic growth.[229] Additionally, China has failed to define and protect intellectual property rights for plant varieties at a fast enough rate to meet its needs.[230] This apprehension may greatly frustrate the development and regulation of transgenic crops.[231] Nevertheless, if the Chinese government

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protection." *Id.* Yet, at this point, "it seems clear that these senior leaders are either too timid to enforce their orders, or the fast-growth political culture they preside over is too entrenched to heed them." *Id.* The Communist Party's failure to achieve its environmental goals "is a sign that the country's environmental problems are at least partly systemic," and that China cannot go green without political change. *Id.*

223. *See* Zhang, *supra* note 4, at 45-46 (describing agricultural and environmental difficulties that threaten China's long-term sustainability).

224. *See generally* Mandel, *supra* note 32 (examining transgenic crops' benefits and risks).

225. *See id.* at 2179-202 (noting uncertainty surrounding transgenic agricultural system).

226. *See id.* (explaining China's possible peril resulting from transgenic crop proliferation).

227. *See* Lightbourne, *supra* note 126, at 241-56 (discussing strength of current regulation).

228. *See* Ding, *supra* note 134, at 348 (explaining that decentralized economic reform "has given local governments wide power and great discretion in dealing with problems in their own territories").

229. *See* Kahn & Yardley, *supra* note 220 (describing insufficient attention to environmental woes at local level).

230. *See* Ding, *supra* note 134, at 339-46 (discussing intellectual property protection for new plant varieties in China). Additionally, "[l]ocal governments currently lack incentives to enforce the intellectual property law because, even though protection of intellectual property rights will benefit the future, it will impose an immediate cost." *Id.* at 348.

231. *See* Kunich, *supra* note 39, at 823-71 (assessing regulatory mechanisms).

closely monitors transgenic crops, China may reap the tremendous rewards biotechnology promises.[232]

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232. *See generally* Haodong Chen et al., *Plant Biology Research Comes of Ages in China,* 18 THE PLANT CELL 11, 2855 (Nov. 2006) (examining benefits transgenic plants present to China).

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